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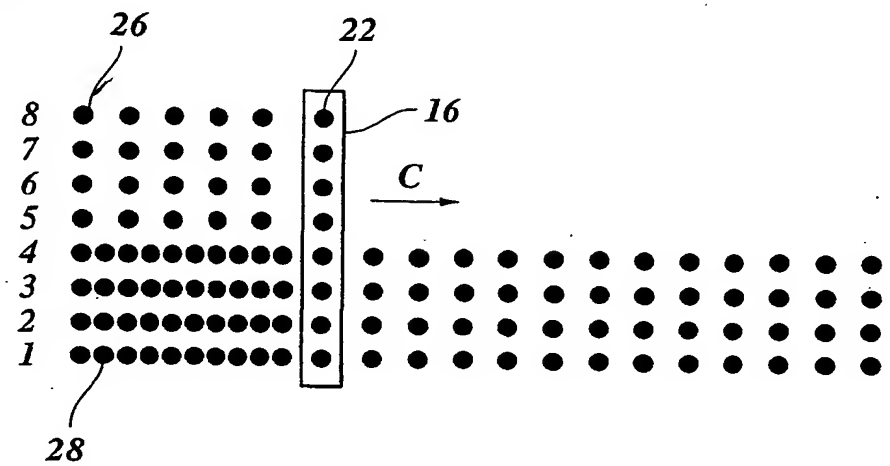
(54) Method of compensating failure of a dot generating unit in a printing system

(57) Method of compensating failure of a dot generating unit (22') in a printing system including a multiple-unit printhead (16) scanning an image receiving medium in line direction and capable of printing several lines (1 - 8) at a time, wherein multi-pass printing and interleaved line feed are employed, wherein when a unit (22') fails, the image information (28') associated with that unit for each pass of the printhead is printed with at least one other unit (22") of the printhead during at least one of the other passes and wherein two-pass printing is performed.

Fig. 2



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Description

[0001] The invention relates to a method of compensating failure of a dot generating unit in a printing system including a multiple-unit printhead scanning an image receiving medium in line direction and capable of printing several lines at a time, wherein multi-pass printing and interleaved line feed are employed and wherein as a unit fails the image information associated with that unit for each pass of the printhead is printed with at least one other unit of the printhead during at least one of the other passes.

[0002] A multiple-unit printhead comprises a plurality of dot generating units arranged in an array which extends perpendicular to the direction of the printing lines on the image receiving medium. Thus, image dots can be printed simultaneously in a plurality of lines, while the printhead performs a single scanning stroke or pass across the image receiving medium. For example, in case of an ink jet printer, each dot generating unit is formed by a single nozzle and an associated actuator system by which ink droplets are jetted out from the nozzle in response to drop demand signal signal supplied thereto in accordance with the image information to be printed.

[0003] Multi-pass printing means that only part of the image information is printed in a single pass of the printhead, i.e. during the movement of the printhead in a unique direction over the entire length of the line, and the printed line is completed in one or more subsequent passes. For example, in case of a two-pass system, every second dot or pixel is printed during the forward pass of the printhead and the missing dots are inserted during the other pass.

[0004] Interleaved line feed means that at least two different units or nozzles of the printhead contribute to the printing of each image line. This is achieved by feeding the image recording medium in the direction normal to the image lines in steps that have a width smaller than the extension of the nozzle array in that direction, so that the nozzle array sweeps at least twice over each location on the receiving medium.

[0005] An example of a printing system with the above features is disclosed in US-A-5 359 355. When, in this system, one of the dot generating units of the printhead becomes inoperative, e.g. because the nozzle has become clogged or air is trapped in the actuator system, the image information can not be printed completely. If, for example, the printhead has eight nozzles and one of them is inoperative, then, in a single-pass system or a system in which no interleaved line feed is employed, every eighth line will be missing on the printed document. In case of a two-pass system with interleaved line feed, every second dot or pixel will be missing in every fourth line.

[0006] JP-A-60-104 335 discloses an ink jet printer, in which additional nozzles are provided in reserve on the printhead. If one of the regular nozzles fails, the printing pattern is changed, so that one or more of the reserve nozzles are activated in order to compensate for the failure. In this system, however, the number of usable nozzles is always limited to the maximal number of consecutive nozzles in the array that are operative. As a result, a certain loss of production of the printer must generally be expected, depending on the location where the nozzle failure occurs.

[0007] It is an object of the present invention to provide an method for compensating failure of a dot generating unit with minimized losses in image quality and production.

[0008] This object is achieved with features indicated in claim 1.

[0009] According to the invention, when n is the number of passes per scan cycle, the unit which prints also the image information associated with the inoperative unit is operated with n times the operating frequency of the other units, and the printhead is moved in scanning direction with the same speed as in the case where all units are operative.

[0010] Thus, when an individual nozzle becomes inoperative, the task of this nozzle is taken over by one of the other regular nozzles of the printhead. It is accordingly not necessary to provide spare nozzles on the printhead, so that a cost reduction can be achieved. Most importantly, however, the failure of the nozzle does not lead to a reduced productivity of the printer, because the image information that normally had to be printed by the inoperative nozzle is printed during one of the other passes that would have been preformed anyway. Thus, if the printhead has eight nozzles for example, and one of these nozzles becomes clogged, the printing process can be continued with printing the full image information of eight lines in each multi-pass cycle, and it is not necessary to perform any extra scan passes.

[0011] It will be understood that the nozzle or nozzles that have to take over the task of the inoperative nozzle will be required to generate more dots than during normal operation. This means that either the scanning speed of the printhead must be reduced or the nozzle must be capable of generating dots at a higher frequency than under normal conditions. However, with existing printheads, e.g. ink jet printheads with piezoelectric actuators, it is generally possible to increase the operating frequency of a few of the nozzles without causing a significant loss of image quality. The reason is that the upper limit for the operating frequency of the dot generating units of a multiple-unit printhead is generally imposed by cross-talk among the various units. For example, in case of an ink jet printhead with piezoelectric actuators, the printhead has to absorb reaction forces caused by the piezoelectric actuators, and this leads to a certain noise which adversely influences the performance of the neighboring nozzles. However, this phenomenon becomes significant only when almost all of the nozzles operate at a high frequency. When only one or two out of the plurality of nozzles are operated at a high-

er frequency, as is the case in the present invention, then the cross-talk effects are generally tolerable. Thus, it is possible according to the invention-to compensate and the failure of one or a few nozzles of the printhead by increasing the operating frequency of some of the other nozzles, so that the printing speed need not be reduced and, nevertheless, the printed image will have a satisfactory quality.

[0012] As a result, the invention permits to significantly extend the maintenance intervals for a printer, especially for a color printer in which the likelyhood of nozzle failure is multiplied because one printhead must be provided for each color.

[0013] More specific features of the invention are indicated in the dependent claims.

[0014] In a preferred embodiment, the function of the dot generating units is automatically checked at regular intervals, for example after each scan cycle or after a certain number of scan cycles, and when it has been detected that an individual unit has become inoperative, the compensation procedure according to the invention is initiated automatically by appropiately changing the timings in which the units are activated and the pattern in which the image information is supplied thereto. This function can easily be implemented in the control software of the printer and can be initiated "on the fly", i.e. without interrupting the operation of the printer.

[0015] An example of a system for automatically detecting a failure of a nozzle in an ink jet printer is disclosed in US-A-4 498 088.

[0016] Preferred embodiments of the invention will now be described in conjunction with the accompanying drawings in which:

Fig. 1 is a schematic perspective view of main components of an ink jet printer;
Fig. 2 - 4 are diagrams illustrating the method according to the invention.

[0017] As is shown in Fig. 1, an ink jet printer comprises a platen 10 for supporting and feeding a sheet of paper 12 which forms an image receiving medium. The platen 10 is rotatable about its longitudinal axis as is indicated by an arrow A.

[0018] A carriage 14 carrying four printheads 16 for four different printing colours is movable back and forth in a direction indicated by arrows B parallel to the platen 10, so that the printheads 16 scan the paper 12 in line direction. The carriage 14 is guided on guide rods 18, 20 and is driven by suitable drive means (not shown) such as a cable or the like.

[0019] In the shown embodiment, each printhead 16 has eight nozzles 22 which form a linear array extending normal to the line direction, i.e. in circumferential direction of the platen 10. In a practical embodiment the number of nozzles per printhead may be considerably larger. Each nozzle 22 is associated with an actuator system which is arranged inside of the printhead 16 and is not shown in the drawing. Together with its associated actuator system each nozzle 22 forms a dot generating unit which can be energized to expel ink droplets onto the paper 12 so that dots are formed on the paper.

[0020] By means of the eight nozzles 22 per printing colour is it possible to print eight lines on the paper 12 during each scan pass of the printheads 16 in the direction B.

[0021] The pattern in which the lines are printed under normal operating conditions of the printer will now be explained in conjunction with Fig. 2, where only one colour component is considered and, accordingly, only one of printheads 16 is shown.

[0022] It shall be assumed that a two-pass system is employed. This means that all odd-numbered pixels or dots 26 of eight consecutive image lines are printed during a forward pass of the printhead 16, i.e. when the printhead 16 moves in the direction of an arrow C in Fig. 2, and all even-numbered dots 28 are printed during the return pass, i.e. when the printhead moves in the opposite direction. It is further assumed that the paper is fed downwardly in Fig. 2. The even-numbered dots 28 of the lower four lines 1 - 4 have been printed already in a previous scan cycle. In the current cycle, the printhead 16 is in the forward pass and prints the odd-numbered dots 26 of the eight lines 1 - 8, so that the lower four lines are completed end every second dot is printed in the upper four lines 5 - 8. At the end of the forward pass, when the printhead has reached the right end of the lines in Fig. 2, the paper will be fed over a distance corresponding to four lines. Thus, in the return pass, the printhead will complete the lines 5 - 8 and will commence the next four lines. Then, the paper is again fed by four lines, and the cycle is repeated.

[0023] Fig. 3 illustrates the case that one of the eight nozzles, designated as 22', has become inoperative, for example because of an air bubble trapped in the actuator system. As a result, the odd-numbered dots 26 cannot be printed in line 7 during the forward pass of the printhead.

[0024] However, when the printhead performs the return pass in the direction of an arrow D in Fig. 4, another one of its nozzles, designated as 22", is in a position suitable for printing the line 7, and this nozzle is now driven to print not only the odd-numbered dots 26 but also the even-numbered dots 28' of this line. In other words, the nozzle 22" performs the task of the inoperative nozzle 22' in addition to its own task. In the next cycle, the nozzle 22" will also print the missing dots in line 3', which the nozzle 22' has failed to print in the present cycle.

[0025] Conversely, if the nozzle 22" were inoperative, its task would be fulfilled "in advance" by the nozzle 22'. Similarly, the remaining three pairs of nozzles of the printhead 16 which are respectively separated by a distance of four lines form partners which can mutually substitute their functions.

[0026] In the example shown in Fig. 4, the nozzle 22'

must operate with twice the normal operating frequency, at least when a "black" area is to be printed, that is, when all dots of the line must actually be printed. In a practical embodiment, the normal operating frequency of the nozzles may be 10 kHz, and the printhead 16 may travel at a speed of 0,8 m/s. When the nozzle 22' fails, the nozzle 22" will operate at 20 kHz, and the scanning speed of the printhead 16 will be kept at 0,8 m/s.

[0027] While a two-pass system has been described above, the principle of the invention is also applicable to a multi-pass system with three or more passes. For example, in case of a three-pass system, each nozzle that becomes inoperative has two partners which are capable of taking-over its function, so that the system would be even more robust. However the nozzles that take-over must be capable of operating with three times the normal operating speed, although they may share their task.

[0028] As is shown in Fig. 1, a detector 30 may be provided for checking in certain intervals, e.g. when the carriage 14 reaches a home position after a complete scan cycle, whether all the nozzles 22 of all printheads 16 are still operative. When a failure of one of the nozzles is detected, the procedure illustrated in Fig. 4 is initiated automatically.

Claims

1. Method of compensating failure of a dot generating unit (22) in a printing system including a multiple-unit printhead (16) scanning an image receiving medium (12) in line direction and capable of printing several lines (1 - 8) at a time, wherein multi-pass printing and interleaved line feed are employed, wherein when a unit (22') fails, the image information (28') associated with that unit for each pass of the printhead is printed with at least one other unit (22") of the printhead during at least one of the other passes, characterized in that when n is the number of passes per scan cycle, the unit (22") which prints also the image information associated with the inoperative unit (22') is operated with n times the operating frequency of the other units (22), and the printhead (16) is moved in scanning direction with the same speed as in the case where all units are operative.

2. Method according to claim 1 wherein two-pass printing is performed.

3. Method according to any of the proceeding claims, wherein failure of a dot generating unit is detected automatically and the compensation procedure is initiated automatically in response to such detection.

Fig. 1

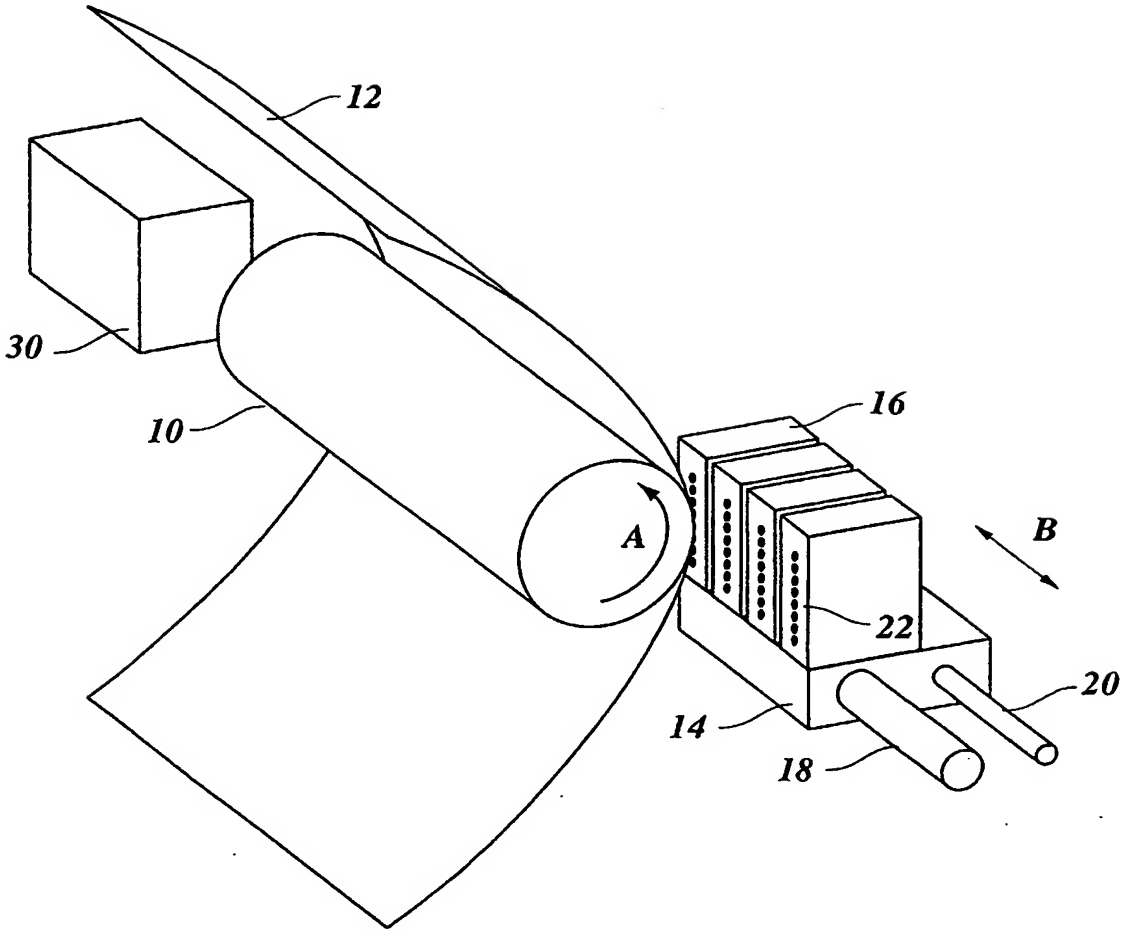


Fig. 2

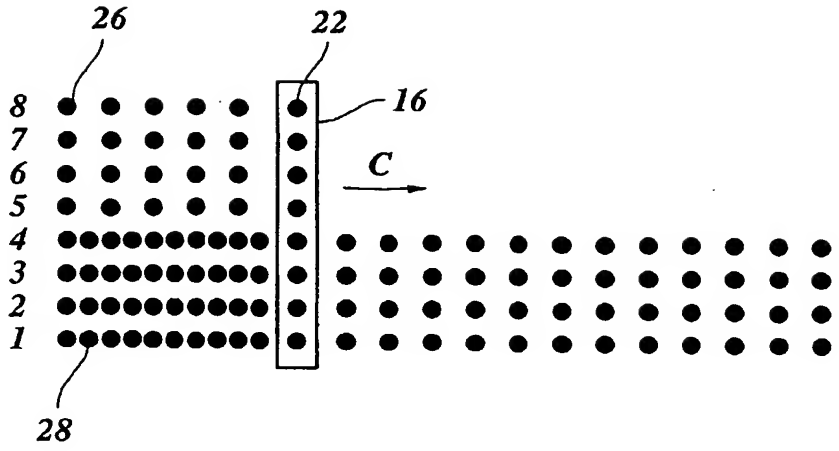


Fig. 3

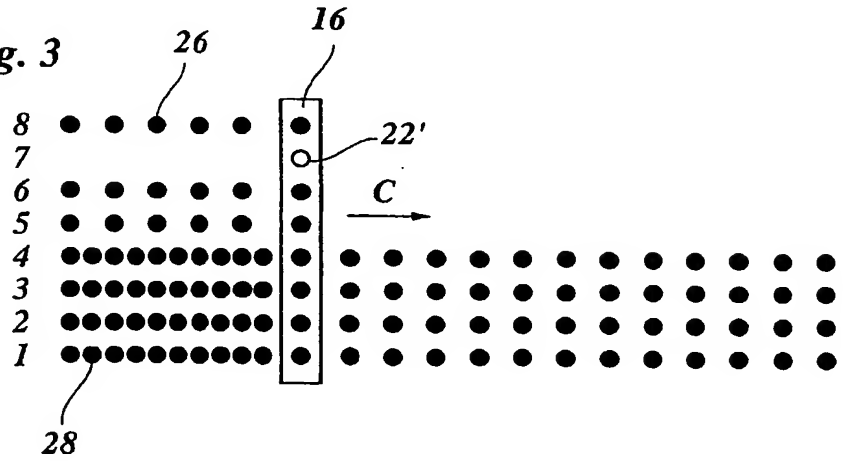
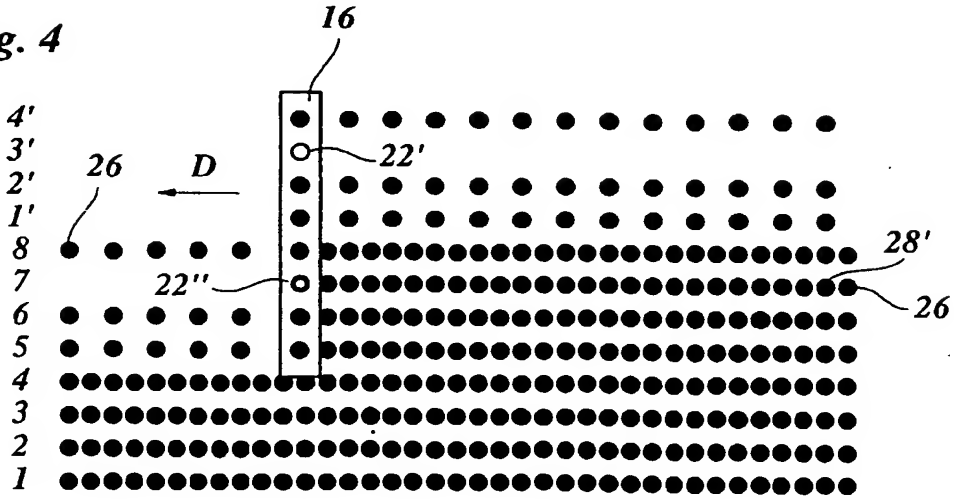


Fig. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 99 20 2646

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION
X Y	EP 0 694 396 A (CANON KK) 31 January 1996 (1996-01-31) * column 8, line 4 - column 21, line 16; figures 1-13 *	1,3 2	G06K15/10 B41J2/21
X A	EP 0 677 390 A (OLIVETTI CANON IND SPA) 18 October 1995 (1995-10-18) * column 6, line 19 - column 12, line 23 *	1 2	
Y	EP 0 616 893 A (CANON KK) 28 September 1994 (1994-09-28) * column 16, line 20 - line 44; figure 9 *	2	
A	EP 0 783 973 A (CANON KK) 16 July 1997 (1997-07-16) * page 6, line 6 - page 12, line 10; figures 5A,5B,6 *	1,3	
A	EP 0 729 838 A (HEWLETT PACKARD CO) 4 September 1996 (1996-09-04) * page 4, line 15 - line 20; figure 1 *	1	
			TECHNICAL FIELDS SEARCHED G06K B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 September 1999	De Groot, R

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13-09-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0694396 A	31-01-1996	JP 8025700 A	30-01-1996
		CA 2154208 A	22-01-1996
		CN 1121000 A	24-04-1996
		SG 35001 A	01-02-1997
EP 0677390 A	18-10-1995	IT T0940286 A	16-10-1995
		JP 7276794 A	24-10-1995
EP 0616893 A	28-09-1994	JP 6278275 A	04-10-1994
		AT 180718 T	15-06-1999
		DE 69418755 D	08-07-1999
EP 0783973 A	16-07-1997	JP 9174824 A	08-07-1997
EP 0729838 A	04-09-1996	US 5644683 A	01-07-1997
		DE 69600807 D	26-11-1998
		DE 69600807 T	11-03-1999
		JP 8252930 A	01-10-1996

EPO FORM P0459

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